Basic Sciences

To help meet the nation's needs for clean energy, inexpensive alternative fuels, and a healthy environment, researchers in the Center for Basic Sciences at NREL are improving our understanding of the science behind renewable energy and energy efficiency technologies.

Technology Focus

These technologies include photovoltaics (solar cells), fuels and energy systems made from biomass (plants and waste products) and hydrogen, and advanced energy storage and transmission systems. Our core competencies include:

- Advanced Materials and Concepts
- Catalyst Design and Synthesis
- Device Design and Analysis
- Electrochemistry
- Heterogeneous and Homogeneous Photoconversion
- High-Temperature Superconductivity
- Materials Growth
- Microbiology and Biochemistry
- Solid State Spectroscopy
- Solid State Theory.

NREL's biological scientists are working to help the nation develop environmentally benign fuels and chemicals. Our research on microorganisms, which includes studies of photosynthetic bacteria and algae, is revealing new ways to produce hydrogen fuel and valuable reduced-carbon compounds. NREL's C_1 Electrocatalysis Team seeks to develop new catalysts for the electrochemical reduction of CO_2 to produce fuels and for the reverse process, the oxidation of fuels to CO_2 with the production of electrical energy.

In photoelectrochemical work, we study the ways in which reactions at the junction of a semiconductor material and a liquid convert solar irradiance into stored chemical energy or electricity. A promising light-based process, photocatalysis, has also been developed at NREL that involves the photo-oxidation of organic pollutants to harmless products such as carbon dioxide and water. We are working on a new photochemical solar cell that is potentially both low cost and efficient; it is based on dye-sensitized titanium dioxide and ruthenium molecules. Our scientists produce various semiconductor structures by means of metal-organic vapor deposition as well as by colloidal chemical synthesis to study the effects of structure on performance.

We are also evaluating the performance, stability, and conversion (sunlight to electricity) efficiency of photoelectrochemical and photovoltaic (PV) solar cells. Applying both theoretical and experimental techniques, we can then explain and manipulate the processes occurring at the semiconductor and in the electrolyte; this work enables us to develop more efficient water-splitting and electricity-generation technologies.

The Computational Materials Science Team performs state-of-the-art theoretical calculations to develop the scientific basis for selection and optimization of the materials used in modern optoelectronic devices.

The Solid State Theory Team conducts fundamental theoretical research into the physics of energy-related materials, including novel compounds, alloys, and nanostructures.

NREL's work in superconductivity has resulted in a new chemical etch that can be used in producing superconducting microelectronic circuits. NREL has also developed a new high-temperature superconducting film consisting of a barium-calcium-copper precursor eletrodeposited on a lanthanum-aluminum-oxide base, or substrate, followed by thallination heat treatment.

The Solid State Spectroscopy Team conducts research to better understand the fundamental mechanisms that limit the performance of PV materials and to synthesize new material architectures for improved PV performance. The team also conducts research on electrochromic materials for "smart" windows, and on transition metal oxides used for solid-state batteries.
An ultrafast laser system, Near-field Scanning Optical Microscopy, also known as NSOM[1] or SNOM[2], is a scanning probe microscopy that allows optical imaging with spatial resolution beyond the diffraction limit.

NREL's Solid State Spectroscopy group is equipped with various continuous-wave lasers and spectrometers that allow high-resolution spectroscopy measurements such as photoluminescence, photoluminescence excitation, Raman, and resonance Raman using both macro- and micro-optics.

Licensing Our Technology
NREL's researchers recently invented the photoelectrochromic window, which makes use of electrochromic materials. Combining a dye-sensitized solar cell with an electrochromic film results in a "smart window" that spontaneously darkens when it is illuminated with sunlight. Smart windows can substantially reduce solar heat gain in buildings, which in turn dramatically lowers the cost of air-conditioning a building in the summer.

For a full listing of NREL's Intellectual Property, please visit our Web site at www.nrel.gov/technologytransfer/available_technologies.html.

Contact Information
If you would like to explore collaborative opportunities with NREL's Basic Science Research Projects, please contact Richard Bolin, 303-275-3028, or by email at richard_bolin@nrel.gov.

For additional technology transfer opportunities, visit our Web site at www.nrel.gov/technologytransfer.